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Rule change and Olympic judo scores, penalties and match duration

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Abstract

Judo is an international combat sport. In the 2009-2013 period, many changes were added, especially after London 2012 Olympics to promote "positive" actions (constant search for maximum score) instead of "negative" actions (avoiding opponents' attacks).

International Judo Federation publishes general statistics (www.judobase.org). This study uses these data to analyze the total match duration, frequency of scores (ippon, wazari, yuko) and penalties (shido) between London 2012 and Rio 2016 (before the rule changes and after the rule changes), considering the different weight categories and competition phases. Data were collected the 2016/09/04; 470 male athletes disputed 1,022 matches and 307 female athletes disputed 698 matches in both Olympic Games.

There are no ethical issues in analyzing these data from open access websites (Morley and Thomas, 2005).

One-way analysis of variance for female and for males separately were conducted, with Tukey test as post hoc. The association between Olympic Games edition and percentage of matches without any score was tested via Chi-square and Cramer's – V effect size was used. Significance level was set at 5%. Eta squared (η^2) was used as effect size.

Results suggest that the rule changes after London 2012 resulted in increased number of ippon only for males, while decreasing the number of yuko and increasing the number of penalties for both genders in Rio 2016.

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One-way analysis of variance for female and for males separately were conducted, with Tukey test as post hoc. The association between Olympic Games edition and percentage of matches without any score was tested via Chi-square and Cramer's – V effect size was used. Significance level was set at 5%. Eta squared (η^2) was used as effect size.

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1) Introduction

Judo is a grappling combat sport derived from ju-jutsu techniques. Although initially created with educational purposes by its founder Jigoro Kano, judo was the first martial arts derived combat sport to become an Olympic sport during Tokyo 1964 Olympics (Brousse and Matsumoto, 1999; Carr, 1993). To become popular worldwide many rule changes were introduced in judo since its Olympic debut such as, weight categories, combat area modification, colored uniforms etc. (Brousse and Matsumoto, 1999; Carr, 1993). However, in the 2009-2013 period many relevant changes were added such as, the World Ranking List introduction, elimination of the penalties and scores equivalence, prohibition of grab leg techniques, many grip breaks restrictions were classified as penalties, weigh-in was placed in the day before competition, the video replay was considered in cases where there would be some doubt concerning the result of given action, and only one referee was inside the competition area (Franchini et al., 2013). Most of these changes were conducted after London 2012 Olympics, and all these changes were conducted to promote "positive" actions such as the constant search for *ippon* (i.e., the judo maximum score) instead of "negative" actions such as avoiding opponent's attacks (Boguszewski, 2011; Ito et al., 2013).

After these rule changes, Franchini et al. (2013) reported that an increase in penalties and a decrease in *wazari* and *yuko* for males and females, while *ippon* scores were found for males only (although disqualifications also increased for this group), during the European Judo Championship disputed after the rule change compared to the edition before it. Thus, only partially the goal to increase *ippon* was achieved, while the increase of penalties was found for both male and females. As scores are preferred by spectators than penalties (Balafoutas et al., 2013), the success of these changes can be questioned. In fact, after the last changes in 2013 the International Judo Federation declared that no further rule modification would take place until the Rio 2016 Olympics (IJF, 2013).

Additionally, the understanding of scores, penalties and total match duration variation across weight categories and competition phases can help coaches to improve the training organization of their athletes to meet these conditions' specific demand. Thus, the present study aimed to compare the total match duration, frequency of scores (*ippon*, *wazari*, *yuko*) and penalties (*shido*) between an Olympic edition before the rule changes (London 2012) and after the rule changes (Rio 2016), considering the different weight categories and competition phases.

2) Methods

2.1 Data sample

The results published on the International Judo Federation official website for judo statistics (www.judobase.org) were retrieved in September 4th 2016. Total match duration, total number of scores (*ippon*, *wazari* and *yuko*) and penalties (*shido* 1 to 4) per match were used to compare males and females separately, concerning weight categories (seven for each gender), competition phase (round of 64 – for males only –, round of 32, round of 16, quarter-finals, repechage, semi-finals, bronze and final matches), and Olympic Games edition (London 2012 and Rio 2016). A total of 1,022 matches disputed by 470 male athletes and a total of 698 matches disputed by 307 female athletes in both Olympic Games.

2.2 Ethics

Morley and Thomas (2005) affirm that there are no ethical issues in analyzing or interpreting these data from open access websites, since all results were obtained in secondary form and not generated by experimentation. Additionally, athletes' personal identification is not reported as only final results were considered.

2.3 Statistics

Data are presented as mean and standard deviation. Time, scores and penalties were compared across weight categories, Olympic Games and tournament phases using separated one-way analysis of variance for female and for males separately. Tukey test was used as post hoc. Eta squared (η^2) was used as effect size. The association between Olympic Games and percentage of matches without any score was tested via Chi-square and Cramer's – V effect size was used. Significance level was set at 5%.

3) Results

3.1 Females

Figure 1 presents the total match time for females from different weight categories (Panel A), Olympic Games edition (Panel B) and competition phase (Panel C).

Panel A

INSERT "FIG 1 - PANEL A"

a = different from the 78 kg weight category ($P < 0.05$)

Panel B

INSERT "FIG 1 - PANEL B"

*** = different from Rio Olympic Games (P < 0.001)

Panel C

INSERT "FIG 1 - PANEL C"

Figure 1: Total match duration for females from different weight categories (Panel A), Olympic Games edition (Panel B) and competition phase (Panel C) (values are mean and standard deviation).

Table 1 presents scores and penalties in matches disputed in different weight categories, Olympic Games edition and phases for females' competition.

Table 1 - Scores and penalties for different weight categories, competition phases and Olympic Games in female judo athletes.

	Ippon (n/athlete/match)	*Wazari* (n/athlete/match)	*Yuko* (n/athlete/match)	Penalties (n/athlete/match)
48 kg (n = 96)	0.23 ± 0.42 (0.14; 0.32)	0.14 ± 0.34 (0.07; 0.20)	0.31 ± 0.59 (0.19; 0.43)	0.71 ± 0.77 (0.54; 0.88)
52 kg (n = 102)	0.25 ± 0.43 (0.16; 0.33)	0.10 ± 0.30 (0.04; 0.16)	0.37 ± 0.63 (0.26; 0.49)	0.76 ± 0.90 (0.59; 0.92)
57 kg (n = 108)	0.20 ± 0.41 (0.12; 0.29)	0.11 ± 0.32 (0.05; 0.17)	0.32 ± 0.73 (0.20; 0.43)	0.81 ± 0.92 (0.65; 0.97)
63 kg (n = 112)	0.25 ± 0.44 (0.17; 0.33)	0.11 ± 0.31 (0.05; 0.17)	0.26 ± 0.48 (0.15; 0.37)	0.61 ± .87 (0.45; 0.77)
70 kg (n = 104)	0.19 ± 0.40 (0.11; 0.28)	0.17 ± 0.38 (0.11; 0.23)	0.25 ± 0.52 (0.14; 0.36)	0.64 ± 0.81 (0.47; 0.80)
78 kg (n = 90)	0.29 ± 0.46 (0.20; 0.38)	0.07 ± 0.25 (0.02; 0.13)	0.23 ± 0.54 (0.11; 0.36)	0.54 ± 0.82 (0.37; 0.72)
> 78 kg (n = 86)	0.31 ± 0.47 (0.22; 0.41)	0.07 ± 0.26 (0.00; 0.14)	0.34 ± 0.64 (0.21; 0.46)	0.77 ± 0.85 (0.59; 0.95)
London Olympics (n = 350)	0.24 ± 0.43 (0.20; 0.29)	0.12 ± 0.33 (0.09; 0.15)	0.35 ± 0.65 (0.29; 0.42)[a]	0.61 ± 0.77 (0.52; 0.70)[a]
Rio Olympics (n = 348)	0.25 ± 0.43 (0.20; 0.29)	0.10 ± 0.30 (0.07; 0.13)	0.24 ± 0.53 (0.18; 0.30)	0.77 ± 0.92 (0.68; 0.86)
Round of 32 (n = 166)	0.28 ± 0.45 (0.22; 0.35)	0.15 ± 0.35 (0.10; 0.19)	0.26 ± 0.53 (0.17; 0.35)	0.61 ± 0.85 (0.48; 0.74)
Round of 16 (n = 224)	0.27 ± 0.45 (0.22; 0.33)	0.07 ± 0.26 (0.03; 0.11)	0.34 ± 0.71 (0.26; 0.41)	0.74 ± 0.88 (0.63; 0.85)
Quarter-finals (n = 112)	0.21 ± 0.41 (0.13; 0.29)	0.15 ± 0.36 (0.09; 0.21)	0.28 ± 0.57 (0.17; 0.39)	0.68 ± 0.84 (0.52; 0.84)
Repechage (n = 56)	0.23 ± 0.43 (0.12; 0.35)	0.07 ± 0.26 (-0.01; 0.15)	0.36 ± 0.59 (0.20; 0.51)	0.91 ± 0.88 (0.69; 1.14)
Semi-finals (n = 56)	0.18 ± 0.39 (0.07; 0.29)	0.11 ± 0.31 (0.03; 0.19)	0.21 ± 0.41 (0.06; 0.37)	0.54 ± 0.74 (0.31; 0.76)
Bronze medal matches (n = 56)	0.20 ± 0.40 (0.08; 0.31)	0.09 ± 0.29 (0.01; 0.17)	0.30 ± 0.46 (0.15; 0.46)	0.79 ± 0.89 (0.56; 1.01)
Finals (n = 28)	0.18 ± 0.39 (0.02; 0.34)	0.18 ± 0.39 (0.06; 0.30)	0.32 ± 0.61 (0.10; 0.54)	0.50 ± 0.69 (0.18; 0.82)

n = number of athletes taking part in each weight category (considering different phases and edition), edition (considering different weight categories and editions) or phase (considering different weight categories and editions); values are mean ± standard deviation and (95% confidence interval; a = different from Rio Olympics ($P < 0.05$).

Weight category

Contest's time differed between weight categories ($F_{6,691}$ = 2.55; P = 0.019; η^2 = 0.022 [small effect]), with longer matches for the 70kg group compared to 78kg group (p = 0.028).

No significant difference was found for *ippon* ($F_{6,691}$ = 0.98; P = 0.441; η^2 = 0.008), *waza-ari* ($F_{6,691}$ = 1.36; P = 0.228; η^2 = 0.012), *yuko* ($F_{6,691}$ = 0.72; P = 0.630; η^2 = 0.006) or number of penalties ($F_{6,691}$ = 1.24; P = 0.283; η^2 = 0.011 [small effect]) between weight categories.

Olympic Games edition

Contest's time differed between Olympic Games edition ($F_{1,691}$ = 75.24; P < 0.001; η^2 = 0.098, [medium effect]), with longer matches in London compared to Rio (p < 0.001).

No significant difference was found for *ippon* ($F_{1,691}$ = 0.05; P = 0.827; η^2 < 0.001), *waza-ari* ($F_{1,691}$ = 0.67; P = 0.414; η^2 < 0.001) concerning Olympics edition. However, *yuko* varied between Olympic Games ($F_{1,691}$ = 6.69; P = 0.010; η^2 = 0.010 [small effect]), with higher number in London compared to Rio (p = 0.010). The number of penalties was also affected by the Olympic edition ($F_{1,691}$ = 5.86; P = 0.016; η^2 = 0.008), with lower values for London compared to Rio (p = 0.016).

There was no association between Olympic Games edition and matches without penalties (χ^2 = 0.975; P = 0.323, V = 0.037).

Phase

The ANOVA indicated a difference between tournament phases ($F_{6,691}$ = 3.93; P < 0.001; η^2 = 0.033 [small effect]), but the post hoc did not confirm any difference (p >0.180).

No significant difference was found for *ippon* ($F_{6,691}$ = 0.99; P = 0.431; η^2 = 0.009), *waza-ari* ($F_{6,691}$ = 1.65; P = 0.131; η^2 = 0.014 [small effect]), *yuko* ($F_{6,691}$ = 0.57; P = 0.754; η^2 = 0.005) or number of penalties ($F_{6,691}$ = 1.66; P = 0.130; η^2 = 0.014[small effect]) between competition phases.

3.2 Males

Figure 2 presents the total match time for males from different weight categories (Panel A), Olympic Games edition (Panel B) and competition phase (Panel C).

Panel A

INSERT "FIG 2 - PANEL A"

Panel B

INSERT "FIG 2 - PANEL B"

*** = different from Rio ($P < 0.001$)

Panel C

INSERT "FIG 2 - PANEL C"

a = different from round of 32 ($P < 0.05$); b = different from round of 64 ($P < 0.05$).

Figure 2: Total match duration for males from different weight categories (Panel A), Olympic Games edition (Panel B) and competition phase (Panel C) (values are mean and standard deviation).

Table 2 presents scores and penalties in matches disputed in different weight categories, Olympic Games edition and phases for males' competition.

Weight category

ANOVA indicated that time differed between weight categories ($F_{6,1015} = 2.14$; $P = 0.047$; $\eta^2 = 0.013$ [small effect]), but the post hoc did not confirm any difference ($p > 0.175$).

No significant difference was found for *ippon* ($F_{6,1015} = 0.20$; $P = 0.977$; $\eta^2 = 0.001$), *waza-ari* ($F_{6,1015} = 0.92$; $P = 0.481$; $\eta^2 = 0.005$), *yuko* ($F_{6,1015} = 1,41$; $P = 0.206$; $\eta^2 = 0.008$) or number of penalties ($F_{6,1015} = 0.54$; $P = 0.780$; $\eta^2 = 0.003$) between weight categories.

Olympic Games edition

Contest's time differed between Olympic Games edition ($F_{1,1020} = 43.23$; $P < 0.001$; $\eta^2 = 0.041$ [small effect]), with longer matches in London compared to Rio ($p < 0.001$).

Significant difference was found for *ippon* ($F_{1,1020} = 5.57$; $P = 0.019$; $\eta^2 = 0.005$), with higher number of *ippon* per match in Rio compared to London ($p = 0.019$). No difference was found for number of *waza-ari* per match ($F_{1,1020} = 0.66$; $P = 0.416$; $\eta^2 = 0.001$) concerning Olympics edition. However, *yuko* varied between Olympic Games ($F_{1,1020} = 9.44$; $P = 0.002$; $\eta^2 = 0.009$), with higher number in London compared to Rio ($p = 0.002$). The number of penalties was also affected by the Olympic edition ($F_{1,1020} = 17.49$; $P < 0.001$; $\eta^2 = 0.017$), with lower values for London compared to Rio ($p < 0.001$).

Phase

The ANOVA indicated a difference between tournament phases ($F_{7,1020} = 10.20$; $P < 0.001$; $\eta^2 = 0.066$ [medium effect]), with round of 16 being longer than round of 32 ($p = 0.011$), quarter-finals being longer than round of 64 ($p < 0.001$) and round of 32 ($p = 0.009$), semi-finals being longer than round of 64 ($p < 0.001$) and round of 32 ($p = 0.002$), bronze medal matches being longer than round of 64 ($p = 0.016$) and round of 32 ($p = 0.041$) matches.

No significant difference was found for *ippon* ($F_{7,1014} = 1.60$; $P = 0.132$; $\eta^2 = 0.011$ [small effect]), *waza-ari* ($F_{7,1014} = 1.46$; $P = 0.179$; $\eta^2 = 0.010$ [small effect]), *yuko* ($F_{7,1014} = 0.36$; $P = 0.926$; $\eta^2 = 0.003$) or number of penalties per match ($F_{7,1014} = 1.73$; $P = 0.098$; $\eta^2 = 0.012$ [small effect]) between competition phases.

There was an association between Olympic Games edition and matches without penalties ($\chi^2 = 4.856$; $P = 0.028$, $V = 0.069$), i.e., the percentage of matches without any single penalty was lower in Rio than in London for female (30.5% vs 35.4%) and for male (22.5% vs 31.1%).

Table 2 - Scores and penalties for different weight categories, competition phases and Olympic Games edition in male judo athletes.

	Ippon (n/athlete/match)	*Wazari* (n/athlete/match)	*Yuko* (n/athlete/match)	Penalties (n/athlete/match)
60 kg (n = 156)	0.26 ± 0.44 (0.19; 0.33)	0.15 ± 0.36 (0.10; 0.21)	0.32 ± 0.58 (0.24; 0.40)	0.78 ± 0.93 (0.64; 0.91)
66 kg (n = 152)	0.26 ± 0.44 (0.19; 0.33)	0.15 ± 0.36 (0.10; 0.21)	0.28 ± 0.55 (0.20; 0.36)	0.76 ± 0.87 (0.62; 0.90)
73 kg (n = 150)	0.26 ± 0.44 (0.19; 0.33)	0.15 ± 0.35 (0.09; 0.20)	0.21 ± 0.44 (0.13; 0.29)	0.83 ± 0.91 (0.69; 0.98)
81 kg (n = 146)	0.25 ± 0.44 (0.18; 0.33)	0.14 ± 0.35 (0.09; 0.20)	0.20 ± 0.43 (0.12; 0.28)	0.85 ± 0.87 (0.71; 0.99)
90 kg (n = 142)	0.28 ± 0.45 (0.20; 0.35)	0.13 ± 0.33 (0.07; 0.18)	0.26 ± 0.47 (0.18; 0.34)	0.86 ± 0.87 (0.71; 1.00)
100 kg (n = 140)	0.28 ± 0.45 (0.21; 0.35)	0.11 ± 0.31 (0.05; 0.16)	0.21 ± 0.49 (0.13; 0.29)	0.71 ± 0.91 (0.57; 0.86)
> 100 kg (n = 136)	0.30 ± 0.46 (0.23; 0.38)	0.08 ± 0.27 (0.02; 0.14)	0.20 ± 0.47 (0.12; 0.28)	0.84 ± 0.82 (0.69; 0.99)
London Olympics (n = 508)	0.24 ± 0.43 (0.20; 0.27)[a]	0.14 ± 0.35 (0.11; 0.17)	0.29 ± 0.54 (0.24; 0.33)[a]	0.69 ± 0.82 (0.61; 0.77)[a]
Rio Olympics (n = 514)	0.30 ± 0.46 (0.27; 0.33)	0.12 ± 0.33 (0.09; 0.15)	0.19 ± 0.44 (0.15; 0.24)	0.92 ± 0.93 (0.84; 0.99)
Round of 64 (n = 54)	0.33 ± 0.48 (0.22; 0.45)	0.09 ± 0.29 (0.00; 0.18)	0.22 ± 0.60 (0.09; 0.35)	0.54 ± 0.82 (0.30; 0.77)
Round of 32 (n = 436)	0.31 ± 0.46 (0.27; 0.35)	0.11 ± 0.32 (0.08; 0.15)	0.25 ± 0.50 (0.20; 0.29)	0.77 ± 0.92 (0.69; 0.85)
Round of 16 (n = 224)	0.27 ± 0.44 (0.21; 0.33)	0.17 ± 0.38 (0.13; 0.22)	0.27 ± 0.52 (0.21; 0.34)	0.90 ± 0.88 (0.78; 1.01)
Quarter-finals (n = 112)	0.19 ± 0.39 (0.11; 0.27)	0.17 ± 0.38 (0.11; 0.23)	0.22 ± 0.48 (0.13; 0.22)	0.85 ± 0.82 (0.68; 1.01)
Repechage (n = 56)	0.21 ± 0.41 (0.10; 0.33)	0.05 ± 0.23 (-0.03; 0.14)	0.23 ± 0.47 (0.10; 0.36)	0.89 ± 0.82 (0.66; 1.12)
Semi-finals (n = 56)	0.21 ± 0.41 (0.10; 0.33)	0.14 ± 0.35 (0.05; 0.23)	0.20 ± 0.40 (0.07; 0.33)	0.93 ± 0.91 (0.70; 1.16)
Bronze medal matches (n = 56)	0.21 ± 0.41 (0.10; 0.33)	0.11 ± 0.31 (0.02; 0.20)	0.20 ± 0.40 (0.07; 0.33)	0.79 ± 0.83 (0.55; 1.02)
Finals (n = 28)	0.21 ± 0.42 (0.05; 0.38)	0.14 ± 0.36 (0.02; 0.27)	0.18 ± 0.48 (-0.01; 0.36)	0.57 ± 0.79 (0.24; 0.90)

n = number of athletes taking part in each weight category (considering different phases and edition), edition (considering different weight categories and editions) or phase (considering different weight categories and editions); values are mean ± standard deviation and (95% confidence interval); a = different from Rio Olympics ($P < 0.05$).

4) Discussion

The main findings of the present study were that there was a decrease in total match time and an increase in total number of penalties from London to Rio Olympics for males (small effect) and females (medium effect). For males, the number of match without any single penalty was associated to the Olympic Games edition, i.e., lower number of matches without any penalty decreased in Rio (small effect). For males, there were significant increase in number of *ippon* and a decrease in number of *yuko* scores, while for females there was a decrease in number of *yuko* scores, from London to Rio Olympics (but in both cases, were negligible effect sizes < 0.01). In contrary, in males' effect size was medium: round of 64 resulted in shorter total time compared to quarter-finals and bronze medal matches, while round of 32 resulted in shorter total time compared to round of 16, quarter-finals and bronze medal matches for males. In females, the only weight category-related difference observed was the longer total match duration in the 70 kg compared to 78 kg weight categories among female competitors.

The total time decrease among female athletes can be explained by the rule change that reduced the time limit from 5 min in London to 4 min in Rio for this gender. The decrease observed among males can be explained by the increase in number of *ippon* scores in Rio compared to London; as this score ends the judo match a higher incidence of *ippon* diminishes the total mean time of combats. The results found indicated that the rules changes were effective to increase the number of *ippon* scores only for males, but negatively affected the number of *yuko* for males (statistically significant, but small effect) and females (small effect) and the number of penalties for both sexes. As the time limit decreased for females in Rio compared to London, this could be the factor explaining the non-increase in ippon. Although no direct comparison was conducted between male and female athletes, the fact that a bigger number of male athletes are classified to compete at Olympic level compared to the female, and consequently a more balanced confrontation probably occurs in the last compared to the first one, can explain why more scores are observed in males' matches compared to females' matches. The increase in penalties of males (small effect) is probably because athletes learned how to deal with the new rule and use it in two main directions: (a) to avoid combat in the last minute of the match, when winning, using illegal actions to avoid the opponent to score, but receiving penalties in this specific period; (b) some athletes may have learned how to win only by making the opponent being penalized. The main results of the London versus Rio comparison are quite similar to the findings from Franchini et al. (2013) concerning 2012 and 2013 European Championships comparison, suggesting that although the rule changes increased the number of *ippon*, this was accompanied by an increase in the number of penalties.

The difference between preliminary phases (round of 64 and round of 32) and other more advanced phases seems to be due to the allocation of top ranked athletes in specific positions during the draw, following the World Ranking List (Franchini and

Julio, 2015), which results in higher ranked athletes against lower ranked athletes in the first rounds and more balanced matches in the quarter-finals (when the top eight best ranked athletes could meet for the first time in the competition) and bronze medal matches. No difference was found in the final matches' total duration and other phases probably due to the fact the two best athletes face each other in this match and both already have a medal guaranteed, which allows them to conduct a more combative match and, consequently, more *ippon* can be scored. The shorter total time in the 78 kg weight category compared to the 70 kg one may be attributed to the presence of the now double Olympic champion Kayla Harrisson, who won all her matches by *ippon*, while in the 70 kg more balanced matches were contested.

During males' competitions, the actual time was 91% in London (273s/300s) and 75.3% in Rio de Janeiro (226s/300s). For females, for whom the contest time was reduced, these values were 92.7% (278s/300s) and 85.0% (204s/240s), respectively.

Finally, the results of the present study suggest that the rule changes after London 2012 resulted in increased number of *yuko* and *ippon* for males, while decreasing the number of *yuko* for females and increasing the number of penalties for both sexes in Rio 2016.

The authors declare that there is no conflict of interest.

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Rule change and Olympic judo scores, penalties and match duration

Abstract

Judo is an international combat sport. In the 2009-2013 period, many changes were added, especially after London 2012 Olympics to promote "positive" actions (constant search for maximum score) instead of "negative" actions (avoiding opponents' attacks).

International Judo Federation publishes general statistics (www.judobase.org). This study uses these data to analyze the total match duration, frequency of scores (ippon, wazari, yuko) and penalties (shido) between London 2012 and Rio 2016 (before the rule changes and after the rule changes), considering the different weight categories and competition phases. Data were collected the 2016/09/04; 470 male athletes disputed 1,022 matches and 307 female athletes disputed 698 matches in both Olympic Games.

There are no ethical issues in analyzing these data from open access websites (Morley and Thomas, 2005).

One-way analysis of variance for female and for males separately were conducted, with Tukey test as post hoc. The association between Olympic Games edition and percentage of matches without any score was tested via Chi-square and Cramer's – V effect size was used. Significance level was set at 5%. Eta squared (η^2) was used as effect size.

Results suggest that the rule changes after London 2012 resulted in increased number of ippon only for males, while decreasing the number of yuko and increasing the number of penalties for both genders in Rio 2016.

Keywords: performance analysis, competition (Olympic Games), technique, scores, combat sports, rules.

1) Introduction

Judo is a grappling combat sport derived from ju-jutsu techniques. Although initially created with educational purposes by its founder Jigoro Kano, judo was the first martial arts derived combat sport to become an Olympic sport during Tokyo 1964 Olympics (Brousse and Matsumoto, 1999; Carr, 1993). To become popular worldwide many rule changes were introduced in judo since its Olympic debut such as, weight categories, combat area modification, colored uniforms etc. (Brousse and Matsumoto, 1999; Carr, 1993). However, in the 2009-2013 period many relevant changes were added such as, the World Ranking List introduction, elimination of the penalties and scores equivalence, prohibition of grab leg techniques, many grip breaks restrictions were classified as penalties, weigh-in was placed in the day before competition, the video replay was considered in cases where there would be some doubt concerning the result of given action, and only one referee was inside the competition area (Franchini et al., 2013). Most of these changes were conducted after London 2012 Olympics, and all these changes were conducted to promote "positive" actions such as the constant search for *ippon* (i.e., the judo maximum score) instead of "negative" actions such as avoiding opponent's attacks (Boguszewski, 2011; Ito et al., 2013).

After these rule changes, Franchini et al. (2013) reported that an increase in penalties and a decrease in *wazari* and *yuko* for males and females, while *ippon* scores were found for males only (although disqualifications also increased for this group), during the European Judo Championship disputed after the rule change compared to the edition before it. Thus, only partially the goal to increase *ippon* was achieved, while the increase of penalties was found for both male and females. As scores are preferred by spectators than penalties (Balafoutas et al., 2013), the success of these changes can be questioned. In fact, after the last changes in 2013 the International Judo Federation declared that no further rule modification would take place until the Rio 2016 Olympics (IJF, 2013).

Additionally, the understanding of scores, penalties and total match duration variation across weight categories and competition phases can help coaches to improve the training organization of their athletes to meet these conditions' specific demand. Thus, the present study aimed to compare the total match duration, frequency of scores (*ippon*, *wazari*, *yuko*) and penalties (*shido*) between an Olympic edition before the rule changes (London 2012) and after the rule changes (Rio 2016), considering the different weight categories and competition phases.

2) Methods

2.1 Data sample

The results published on the International Judo Federation official website for judo statistics (www.judobase.org) were retrieved in September 4th 2016. Total match duration, total number of scores (*ippon*, *wazari* and *yuko*) and penalties (*shido* 1 to 4) per match were used to compare males and females separately, concerning weight categories (seven for each gender), competition phase (round of 64 – for males only –, round of 32, round of 16, quarter-finals, repechage, semi-finals, bronze and final matches), and Olympic Games edition (London 2012 and Rio 2016). A total of 1,022 matches disputed by 470 male athletes and a total of 698 matches disputed by 307 female athletes in both Olympic Games.

2.2 Ethics

Morley and Thomas (2005) affirm that there are no ethical issues in analyzing or interpreting these data from open access websites, since all results were obtained in secondary form and not generated by experimentation. Additionally, athletes' personal identification is not reported as only final results were considered.

2.3 Statistics

Data are presented as mean and standard deviation. Time, scores and penalties were compared across weight categories, Olympic Games and tournament phases using separated one-way analysis of variance for female and for males separately. Tukey test was used as post hoc. Eta squared (η^2) was used as effect size. The association between Olympic Games and percentage of matches without any score was tested via Chi-square and Cramer's – V effect size was used. Significance level was set at 5%.

3) Results

3.1 Females

Figure 1 presents the total match time for females from different weight categories (Panel A), Olympic Games edition (Panel B) and competition phase (Panel C).

Panel A

INSERT "FIG 1 - PANEL A"

a = different from the 78 kg weight category ($P < 0.05$)

Panel B

INSERT "FIG 1 - PANEL B"

*** = different from Rio Olympic Games (P < 0.001)

Panel C

INSERT "FIG 1 - PANEL C"

Figure 1: Total match duration for females from different weight categories (Panel A), Olympic Games edition (Panel B) and competition phase (Panel C) (values are mean and standard deviation).

Table 1 presents scores and penalties in matches disputed in different weight categories, Olympic Games edition and phases for females' competition.

Table 1 - Scores and penalties for different weight categories, competition phases and Olympic Games in female judo athletes.

	Ippon (n/athlete/match)	*Wazari* (n/athlete/match)	*Yuko* (n/athlete/match)	Penalties (n/athlete/match)
48 kg (n = 96)	0.23 ± 0.42 (0.14; 0.32)	0.14 ± 0.34 (0.07; 0.20)	0.31 ± 0.59 (0.19; 0.43)	0.71 ± 0.77 (0.54; 0.88)
52 kg (n = 102)	0.25 ± 0.43 (0.16; 0.33)	0.10 ± 0.30 (0.04; 0.16)	0.37 ± 0.63 (0.26; 0.49)	0.76 ± 0.90 (0.59; 0.92)
57 kg (n = 108)	0.20 ± 0.41 (0.12; 0.29)	0.11 ± 0.32 (0.05; 0.17)	0.32 ± 0.73 (0.20; 0.43)	0.81 ± 0.92 (0.65; 0.97)
63 kg (n = 112)	0.25 ± 0.44 (0.17; 0.33)	0.11 ± 0.31 (0.05; 0.17)	0.26 ± 0.48 (0.15; 0.37)	0.61 ± .87 (0.45; 0.77)
70 kg (n = 104)	0.19 ± 0.40 (0.11; 0.28)	0.17 ± 0.38 (0.11; 0.23)	0.25 ± 0.52 (0.14; 0.36)	0.64 ± 0.81 (0.47; 0.80)
78 kg (n = 90)	0.29 ± 0.46 (0.20; 0.38)	0.07 ± 0.25 (0.02; 0.13)	0.23 ± 0.54 (0.11; 0.36)	0.54 ± 0.82 (0.37; 0.72)
> 78 kg (n = 86)	0.31 ± 0.47 (0.22; 0.41)	0.07 ± 0.26 (0.00; 0.14)	0.34 ± 0.64 (0.21; 0.46)	0.77 ± 0.85 (0.59; 0.95)
London Olympics (n = 350)	0.24 ± 0.43 (0.20; 0.29)	0.12 ± 0.33 (0.09; 0.15)	0.35 ± 0.65 (0.29; 0.42)[a]	0.61 ± 0.77 (0.52; 0.70)[a]
Rio Olympics (n = 348)	0.25 ± 0.43 (0.20; 0.29)	0.10 ± 0.30 (0.07; 0.13)	0.24 ± 0.53 (0.18; 0.30)	0.77 ± 0.92 (0.68; 0.86)
Round of 32 (n = 166)	0.28 ± 0.45 (0.22; 0.35)	0.15 ± 0.35 (0.10; 0.19)	0.26 ± 0.53 (0.17; 0.35)	0.61 ± 0.85 (0.48; 0.74)
Round of 16 (n = 224)	0.27 ± 0.45 (0.22; 0.33)	0.07 ± 0.26 (0.03; 0.11)	0.34 ± 0.71 (0.26; 0.41)	0.74 ± 0.88 (0.63; 0.85)
Quarter-finals (n = 112)	0.21 ± 0.41 (0.13; 0.29)	0.15 ± 0.36 (0.09; 0.21)	0.28 ± 0.57 (0.17; 0.39)	0.68 ± 0.84 (0.52; 0.84)
Repechage (n = 56)	0.23 ± 0.43 (0.12; 0.35)	0.07 ± 0.26 (-0.01; 0.15)	0.36 ± 0.59 (0.20; 0.51)	0.91 ± 0.88 (0.69; 1.14)
Semi-finals (n = 56)	0.18 ± 0.39 (0.07; 0.29)	0.11 ± 0.31 (0.03; 0.19)	0.21 ± 0.41 (0.06; 0.37)	0.54 ± 0.74 (0.31; 0.76)
Bronze medal matches (n = 56)	0.20 ± 0.40 (0.08; 0.31)	0.09 ± 0.29 (0.01; 0.17)	0.30 ± 0.46 (0.15; 0.46)	0.79 ± 0.89 (0.56; 1.01)
Finals (n = 28)	0.18 ± 0.39 (0.02; 0.34)	0.18 ± 0.39 (0.06; 0.30)	0.32 ± 0.61 (0.10; 0.54)	0.50 ± 0.69 (0.18; 0.82)

n = number of athletes taking part in each weight category (considering different phases and edition), edition (considering different weight categories and editions) or phase (considering different weight categories and editions); values are mean ± standard deviation and (95% confidence interval; a = different from Rio Olympics ($P < 0.05$).

Weight category

Contest's time differed between weight categories ($F_{6,691}$ = 2.55; P = 0.019; η^2 = 0.022 [small effect]), with longer matches for the 70kg group compared to 78kg group (p = 0.028).

No significant difference was found for *ippon* ($F_{6,691}$ = 0.98; P = 0.441; η^2 = 0.008), *waza-ari* ($F_{6,691}$ = 1.36; P = 0.228; η^2 = 0.012), *yuko* ($F_{6,691}$ = 0.72; P = 0.630; η^2 = 0.006) or number of penalties ($F_{6,691}$ = 1.24; P = 0.283; η^2 = 0.011 [small effect]) between weight categories.

Olympic Games edition

Contest's time differed between Olympic Games edition ($F_{1,691}$ = 75.24; P < 0.001; η^2 = 0.098, [medium effect]), with longer matches in London compared to Rio (p < 0.001).

No significant difference was found for *ippon* ($F_{1,691}$ = 0.05; P = 0.827; η^2 < 0.001), *waza-ari* ($F_{1,691}$ = 0.67; P = 0.414; η^2 < 0.001) concerning Olympics edition. However, *yuko* varied between Olympic Games ($F_{1,691}$ = 6.69; P = 0.010; η^2 = 0.010 [small effect]), with higher number in London compared to Rio (p = 0.010). The number of penalties was also affected by the Olympic edition ($F_{1,691}$ = 5.86; P = 0.016; η^2 = 0.008), with lower values for London compared to Rio (p = 0.016).

There was no association between Olympic Games edition and matches without penalties (χ^2 = 0.975; P = 0.323, V = 0.037).

Phase

The ANOVA indicated a difference between tournament phases ($F_{6,691}$ = 3.93; P < 0.001; η^2 = 0.033 [small effect]), but the post hoc did not confirm any difference (p >0.180).

No significant difference was found for *ippon* ($F_{6,691}$ = 0.99; P = 0.431; η^2 = 0.009), *waza-ari* ($F_{6,691}$ = 1.65; P = 0.131; η^2 = 0.014 [small effect]), *yuko* ($F_{6,691}$ = 0.57; P = 0.754; η^2 = 0.005) or number of penalties ($F_{6,691}$ = 1.66; P = 0.130; η^2 = 0.014[small effect]) between competition phases.

3.2 Males

Figure 2 presents the total match time for males from different weight categories (Panel A), Olympic Games edition (Panel B) and competition phase (Panel C).

Panel A

INSERT "FIG 2 - PANEL A"

Panel B

INSERT "FIG 2 - PANEL B"

*** = different from Rio ($P < 0.001$)

Panel C

INSERT "FIG 2 - PANEL C"

a = different from round of 32 ($P < 0.05$); b = different from round of 64 ($P < 0.05$).

Figure 2: Total match duration for males from different weight categories (Panel A), Olympic Games edition (Panel B) and competition phase (Panel C) (values are mean and standard deviation).

Table 2 presents scores and penalties in matches disputed in different weight categories, Olympic Games edition and phases for males' competition.

Weight category

ANOVA indicated that time differed between weight categories ($F_{6,1015} = 2.14$; $P = 0.047$; $\eta^2 = 0.013$ [small effect]), but the post hoc did not confirm any difference ($p > 0.175$).

No significant difference was found for *ippon* ($F_{6,1015} = 0.20$; $P = 0.977$; $\eta^2 = 0.001$), *waza-ari* ($F_{6,1015} = 0.92$; $P = 0.481$; $\eta^2 = 0.005$), *yuko* ($F_{6,1015} = 1,41$; $P = 0.206$; $\eta^2 = 0.008$) or number of penalties ($F_{6,1015} = 0.54$; $P = 0.780$; $\eta^2 = 0.003$) between weight categories.

Olympic Games edition

Contest's time differed between Olympic Games edition ($F_{1,1020} = 43.23$; $P < 0.001$; $\eta^2 = 0.041$ [small effect]), with longer matches in London compared to Rio ($p < 0.001$).

Significant difference was found for *ippon* ($F_{1,1020} = 5.57$; $P = 0.019$; $\eta^2 = 0.005$), with higher number of *ippon* per match in Rio compared to London ($p = 0.019$). No difference was found for number of *waza-ari* per match ($F_{1,1020} = 0.66$; $P = 0.416$; $\eta^2 = 0.001$) concerning Olympics edition. However, *yuko* varied between Olympic Games ($F_{1,1020} = 9.44$; $P = 0.002$; $\eta^2 = 0.009$), with higher number in London compared to Rio ($p = 0.002$). The number of penalties was also affected by the Olympic edition ($F_{1,1020} = 17.49$; $P < 0.001$; $\eta^2 = 0.017$), with lower values for London compared to Rio ($p < 0.001$).

Phase

The ANOVA indicated a difference between tournament phases ($F_{7,1020} = 10.20$; $P < 0.001$; $\eta^2 = 0.066$ [medium effect]), with round of 16 being longer than round of 32 ($p = 0.011$), quarter-finals being longer than round of 64 ($p < 0.001$) and round of 32 ($p = 0.009$), semi-finals being longer than round of 64 ($p < 0.001$) and round of 32 ($p = 0.002$), bronze medal matches being longer than round of 64 ($p = 0.016$) and round of 32 ($p = 0.041$) matches.

No significant difference was found for *ippon* ($F_{7,1014} = 1.60$; $P = 0.132$; $\eta^2 = 0.011$ [small effect]), *waza-ari* ($F_{7,1014} = 1.46$; $P = 0.179$; $\eta^2 = 0.010$ [small effect]), *yuko* ($F_{7,1014} = 0.36$; $P = 0.926$; $\eta^2 = 0.003$) or number of penalties per match ($F_{7,1014} = 1.73$; $P = 0.098$; $\eta^2 = 0.012$ [small effect]) between competition phases.

There was an association between Olympic Games edition and matches without penalties ($\chi^2 = 4.856$; $P = 0.028$, $V = 0.069$), i.e., the percentage of matches without any single penalty was lower in Rio than in London for female (30.5% vs 35.4%) and for male (22.5% vs 31.1%).

Table 2 - Scores and penalties for different weight categories, competition phases and Olympic Games edition in male judo athletes.

	Ippon (n/athlete/match)	*Wazari* (n/athlete/match)	*Yuko* (n/athlete/match)	Penalties (n/athlete/match)
60 kg (n = 156)	0.26 ± 0.44 (0.19; 0.33)	0.15 ± 0.36 (0.10; 0.21)	0.32 ± 0.58 (0.24; 0.40)	0.78 ± 0.93 (0.64; 0.91)
66 kg (n = 152)	0.26 ± 0.44 (0.19; 0.33)	0.15 ± 0.36 (0.10; 0.21)	0.28 ± 0.55 (0.20; 0.36)	0.76 ± 0.87 (0.62; 0.90)
73 kg (n = 150)	0.26 ± 0.44 (0.19; 0.33)	0.15 ± 0.35 (0.09; 0.20)	0.21 ± 0.44 (0.13; 0.29)	0.83 ± 0.91 (0.69; 0.98)
81 kg (n = 146)	0.25 ± 0.44 (0.18; 0.33)	0.14 ± 0.35 (0.09; 0.20)	0.20 ± 0.43 (0.12; 0.28)	0.85 ± 0.87 (0.71; 0.99)
90 kg (n = 142)	0.28 ± 0.45 (0.20; 0.35)	0.13 ± 0.33 (0.07; 0.18)	0.26 ± 0.47 (0.18; 0.34)	0.86 ± 0.87 (0.71; 1.00)
100 kg (n = 140)	0.28 ± 0.45 (0.21; 0.35)	0.11 ± 0.31 (0.05; 0.16)	0.21 ± 0.49 (0.13; 0.29)	0.71 ± 0.91 (0.57; 0.86)
> 100 kg (n = 136)	0.30 ± 0.46 (0.23; 0.38)	0.08 ± 0.27 (0.02; 0.14)	0.20 ± 0.47 (0.12; 0.28)	0.84 ± 0.82 (0.69; 0.99)
London Olympics (n = 508)	0.24 ± 0.43 (0.20; 0.27)[a]	0.14 ± 0.35 (0.11; 0.17)	0.29 ± 0.54 (0.24; 0.33)[a]	0.69 ± 0.82 (0.61; 0.77)[a]
Rio Olympics (n = 514)	0.30 ± 0.46 (0.27; 0.33)	0.12 ± 0.33 (0.09; 0.15)	0.19 ± 0.44 (0.15; 0.24)	0.92 ± 0.93 (0.84; 0.99)
Round of 64 (n = 54)	0.33 ± 0.48 (0.22; 0.45)	0.09 ± 0.29 (0.00; 0.18)	0.22 ± 0.60 (0.09; 0.35)	0.54 ± 0.82 (0.30; 0.77)
Round of 32 (n = 436)	0.31 ± 0.46 (0.27; 0.35)	0.11 ± 0.32 (0.08; 0.15)	0.25 ± 0.50 (0.20; 0.29)	0.77 ± 0.92 (0.69; 0.85)
Round of 16 (n = 224)	0.27 ± 0.44 (0.21; 0.33)	0.17 ± 0.38 (0.13; 0.22)	0.27 ± 0.52 (0.21; 0.34)	0.90 ± 0.88 (0.78; 1.01)
Quarter-finals (n = 112)	0.19 ± 0.39 (0.11; 0.27)	0.17 ± 0.38 (0.11; 0.23)	0.22 ± 0.48 (0.13; 0.22)	0.85 ± 0.82 (0.68; 1.01)
Repechage (n = 56)	0.21 ± 0.41 (0.10; 0.33)	0.05 ± 0.23 (-0.03; 0.14)	0.23 ± 0.47 (0.10; 0.36)	0.89 ± 0.82 (0.66; 1.12)
Semi-finals (n = 56)	0.21 ± 0.41 (0.10; 0.33)	0.14 ± 0.35 (0.05; 0.23)	0.20 ± 0.40 (0.07; 0.33)	0.93 ± 0.91 (0.70; 1.16)
Bronze medal matches (n = 56)	0.21 ± 0.41 (0.10; 0.33)	0.11 ± 0.31 (0.02; 0.20)	0.20 ± 0.40 (0.07; 0.33)	0.79 ± 0.83 (0.55; 1.02)
Finals (n = 28)	0.21 ± 0.42 (0.05; 0.38)	0.14 ± 0.36 (0.02; 0.27)	0.18 ± 0.48 (-0.01; 0.36)	0.57 ± 0.79 (0.24; 0.90)

n = number of athletes taking part in each weight category (considering different phases and edition), edition (considering different weight categories and editions) or phase (considering different weight categories and editions); values are mean ± standard deviation and (95% confidence interval); a = different from Rio Olympics ($P < 0.05$).

4) Discussion

The main findings of the present study were that there was a decrease in total match time and an increase in total number of penalties from London to Rio Olympics for males (small effect) and females (medium effect). For males, the number of match without any single penalty was associated to the Olympic Games edition, i.e., lower number of matches without any penalty decreased in Rio (small effect). For males, there were significant increase in number of *ippon* and a decrease in number of *yuko* scores, while for females there was a decrease in number of *yuko* scores, from London to Rio Olympics (but in both cases, were negligible effect sizes < 0.01). In contrary, in males' effect size was medium: round of 64 resulted in shorter total time compared to quarter-finals and bronze medal matches, while round of 32 resulted in shorter total time compared to round of 16, quarter-finals and bronze medal matches for males. In females, the only weight category-related difference observed was the longer total match duration in the 70 kg compared to 78 kg weight categories among female competitors.

The total time decrease among female athletes can be explained by the rule change that reduced the time limit from 5 min in London to 4 min in Rio for this gender. The decrease observed among males can be explained by the increase in number of *ippon* scores in Rio compared to London; as this score ends the judo match a higher incidence of *ippon* diminishes the total mean time of combats. The results found indicated that the rules changes were effective to increase the number of *ippon* scores only for males, but negatively affected the number of *yuko* for males (statistically significant, but small effect) and females (small effect) and the number of penalties for both sexes. As the time limit decreased for females in Rio compared to London, this could be the factor explaining the non-increase in ippon. Although no direct comparison was conducted between male and female athletes, the fact that a bigger number of male athletes are classified to compete at Olympic level compared to the female, and consequently a more balanced confrontation probably occurs in the last compared to the first one, can explain why more scores are observed in males' matches compared to females' matches. The increase in penalties of males (small effect) is probably because athletes learned how to deal with the new rule and use it in two main directions: (a) to avoid combat in the last minute of the match, when winning, using illegal actions to avoid the opponent to score, but receiving penalties in this specific period; (b) some athletes may have learned how to win only by making the opponent being penalized. The main results of the London versus Rio comparison are quite similar to the findings from Franchini et al. (2013) concerning 2012 and 2013 European Championships comparison, suggesting that although the rule changes increased the number of *ippon*, this was accompanied by an increase in the number of penalties.

The difference between preliminary phases (round of 64 and round of 32) and other more advanced phases seems to be due to the allocation of top ranked athletes in specific positions during the draw, following the World Ranking List (Franchini and

Julio, 2015), which results in higher ranked athletes against lower ranked athletes in the first rounds and more balanced matches in the quarter-finals (when the top eight best ranked athletes could meet for the first time in the competition) and bronze medal matches. No difference was found in the final matches' total duration and other phases probably due to the fact the two best athletes face each other in this match and both already have a medal guaranteed, which allows them to conduct a more combative match and, consequently, more *ippon* can be scored. The shorter total time in the 78 kg weight category compared to the 70 kg one may be attributed to the presence of the now double Olympic champion Kayla Harrisson, who won all her matches by *ippon*, while in the 70 kg more balanced matches were contested.

During males' competitions, the actual time was 91% in London (273s/300s) and 75.3% in Rio de Janeiro (226s/300s). For females, for whom the contest time was reduced, these values were 92.7% (278s/300s) and 85.0% (204s/240s), respectively.

Finally, the results of the present study suggest that the rule changes after London 2012 resulted in increased number of *yuko* and *ippon* for males, while decreasing the number of *yuko* for females and increasing the number of penalties for both sexes in Rio 2016.

The authors declare that there is no conflict of interest.

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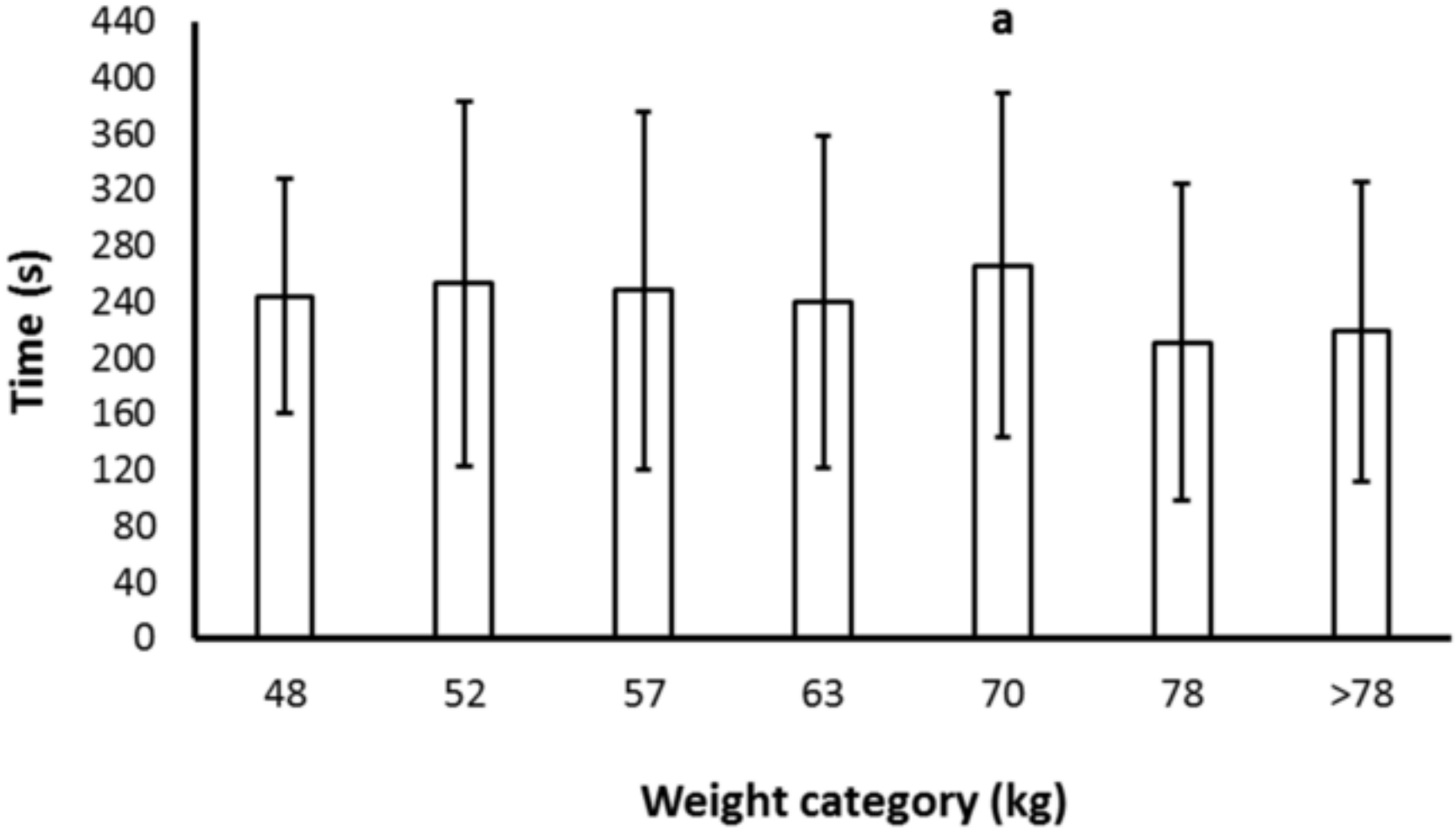
FIG 1 - PANEL A


a
440
400
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240
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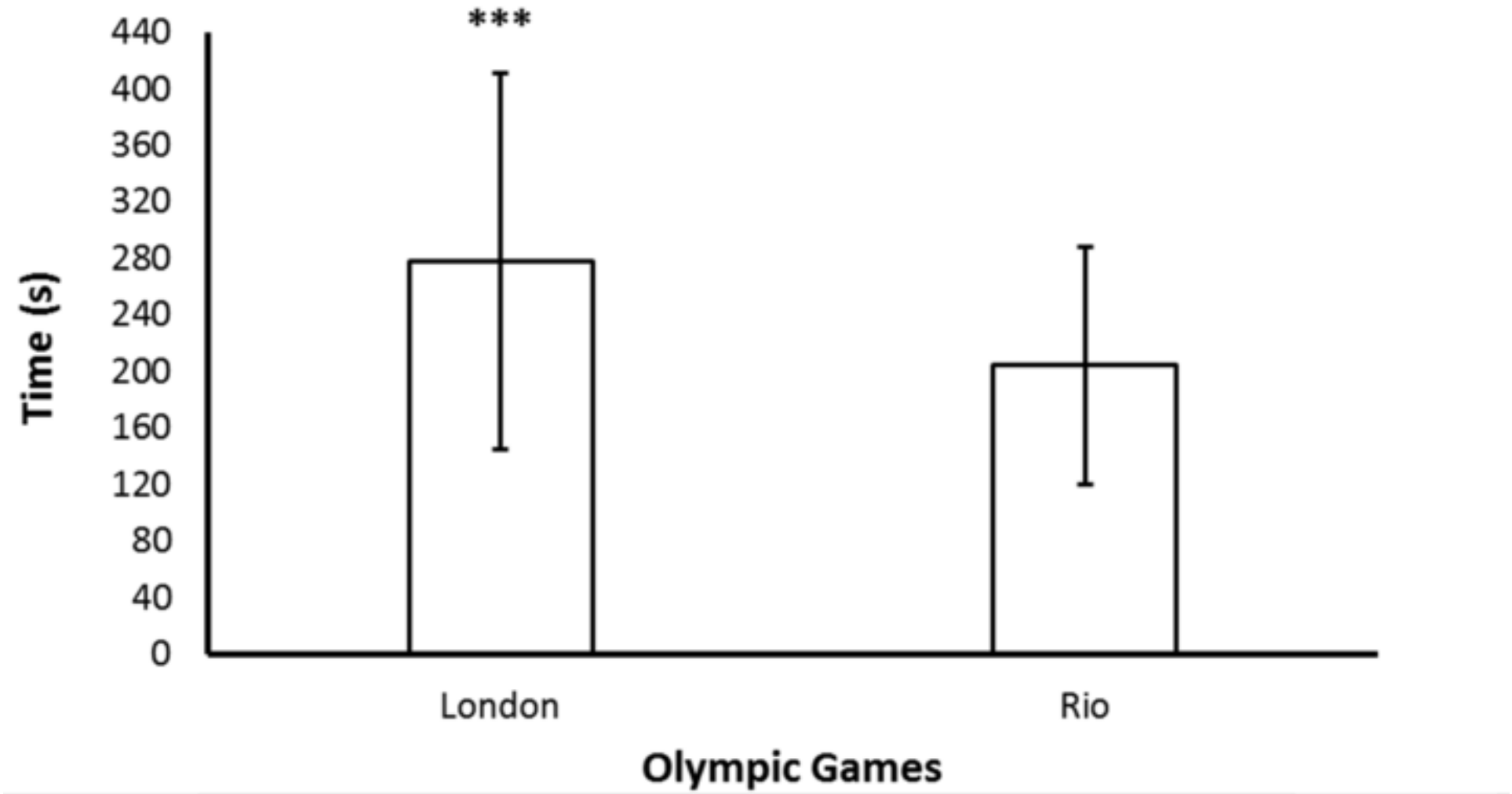
Time (s)
48
52
57
63
70
78
>78
Weight category (kg)

FIG 1 - PANEL B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440
400
360
320
280
240
200
160
120
80
40
0
Time (s)
London
Rio
Olympic Games

FIG 1 - PANEL C

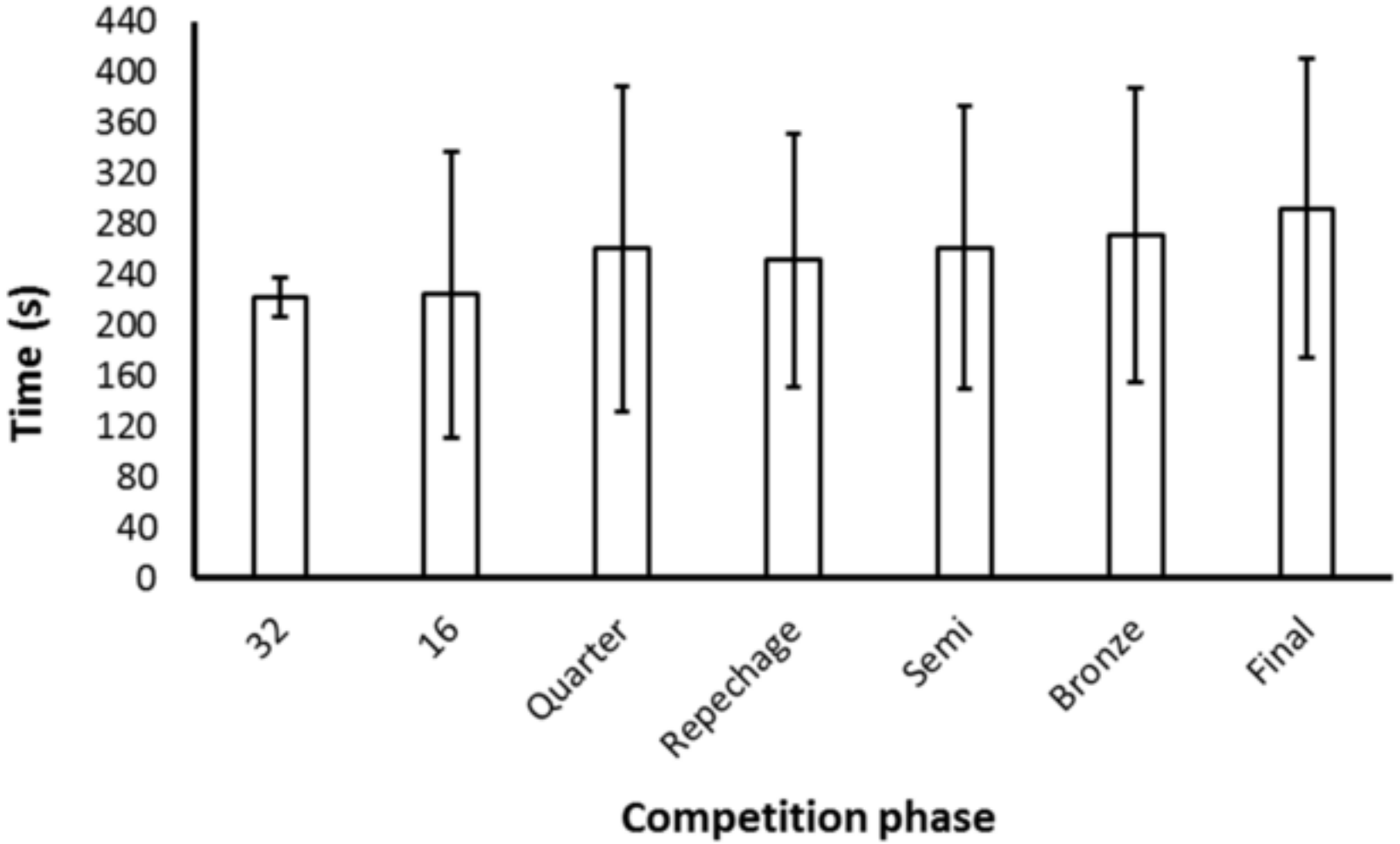

Time (s)
440
400
360
320
280
240
200
160
120
80
40
0
32
16
Quarter
Repechage
Semi
Bronze
Final
Competition phase

FIG 2 - PANEL A

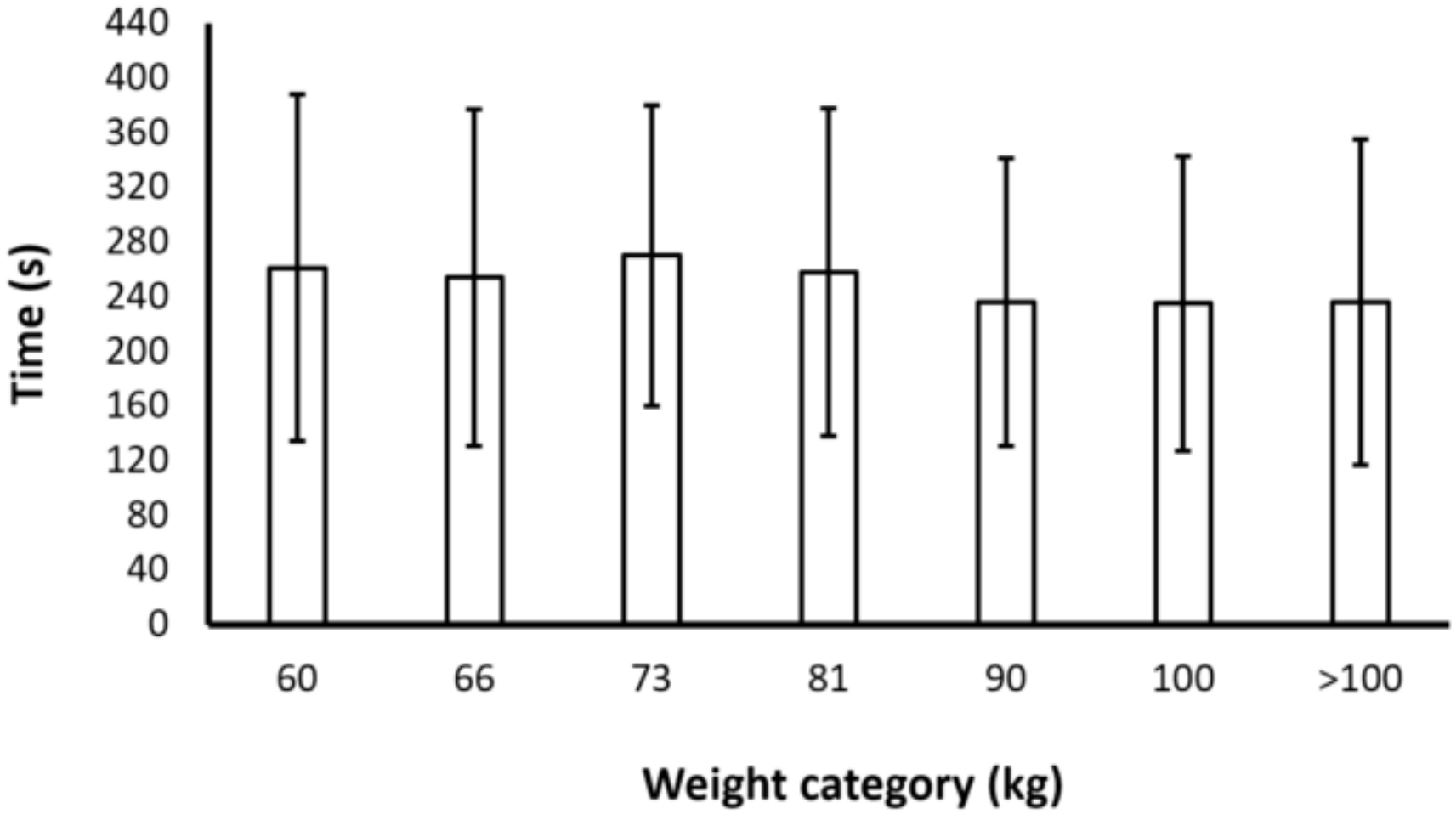

440
400
360
320
280
240
200
160
120
80
40
0
Time (s)
60
66
73
81
90
100
>100
Weight category (kg)

FIG 2 - PANEL B

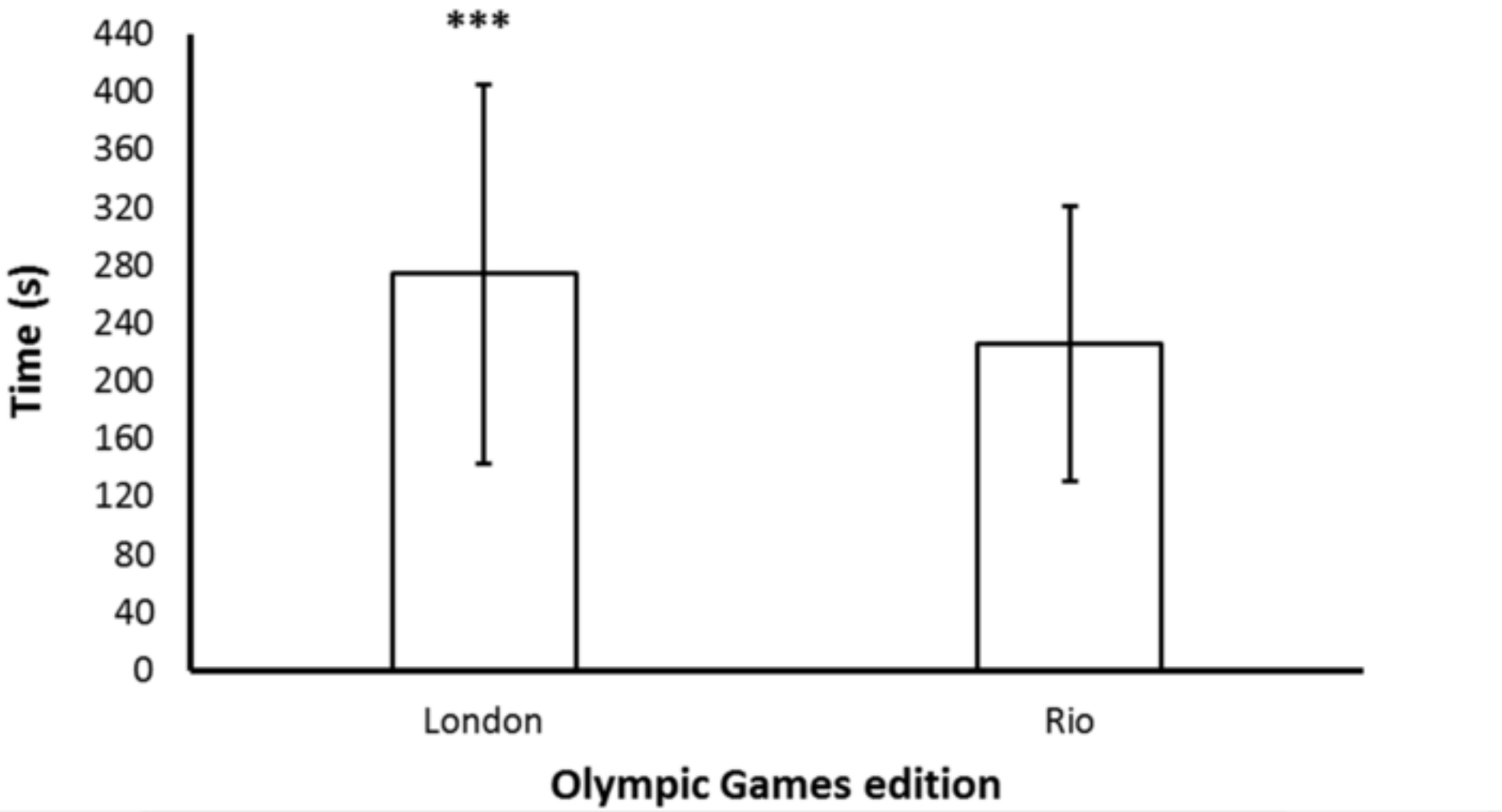
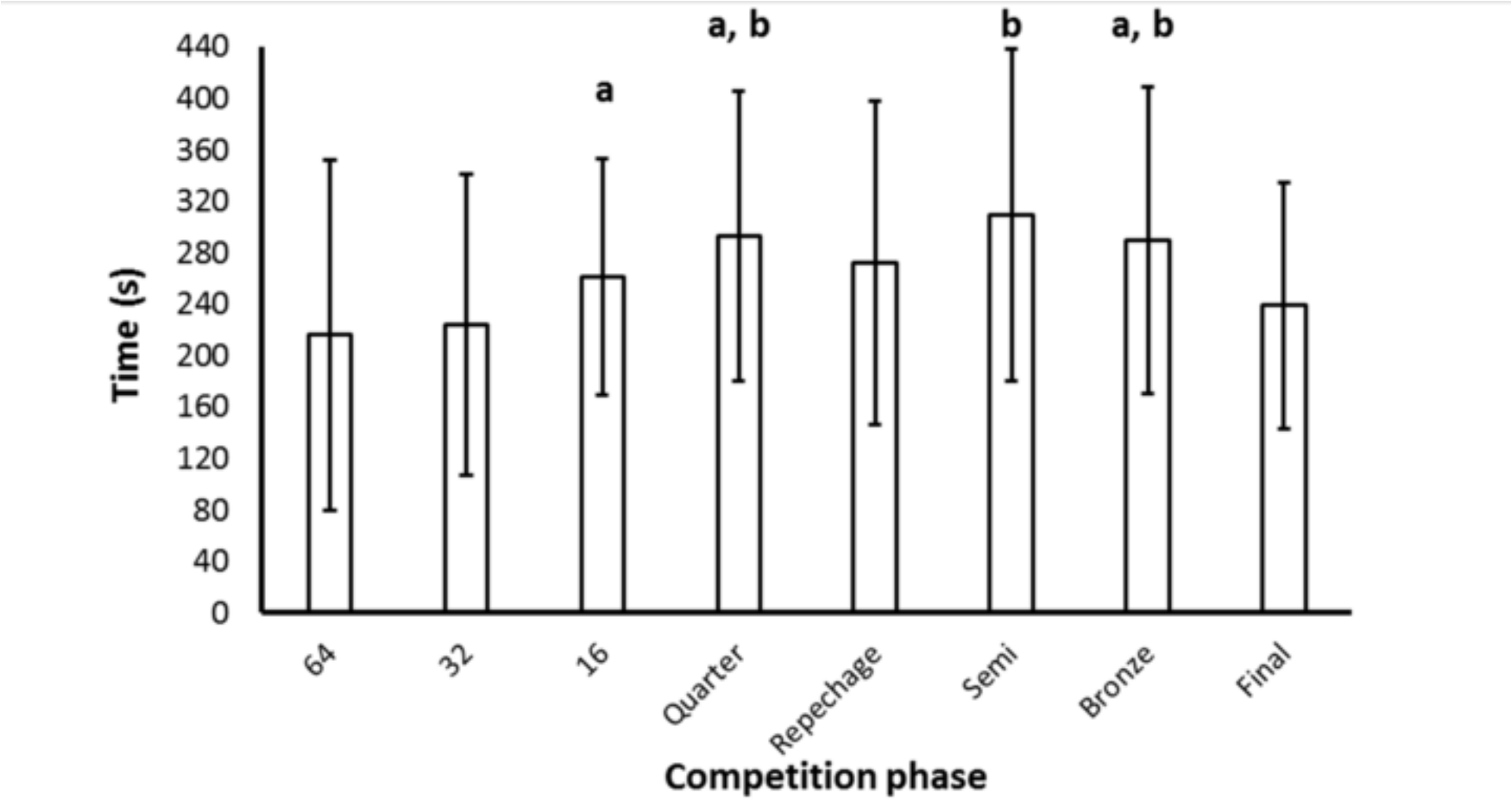

***
440
400
360
320
280
240
200
160
120
80
40
0
Time (s)
London
Rio
Olympic Games edition

FIG 2 - PANEL C


a, b
b
a, b
a
440
400
360
320
280
240
200
160
120
80
40
0
Time (s)
64
32
16
Quarter
Repechage
Semi
Bronze
Final
Competition phase